Flue Gas and Air per kg of Fuel from Orsat Analysis

Mass and volume of dry flue gas and the air supplied per kg of fuel from the carbon in the fuel and the dry flue gas analysis, by the carbon balance.

Method: Carbon and nitrogen balances (textbook); IUPAC 2013 molar masses; ASME PTC 4-2013 air

Input parameters

Unit system: SI

Parameter	Value	Unit
Carbon in the fuel (burnt carbon, by mass)	60.000	%
Carbon dioxide (dry, by volume)	12.000	%
Oxygen (dry, by volume)	7.0000	%
Carbon monoxide (dry, by volume)	0.50000	%

Calculated results

Parameter	Value	Unit
Dry flue gas per kg of fuel	12.122	kg/kg
Dry flue gas per kg of fuel at 0 °C, 101.325 kPa	8.9574	Nm³/kg
Air supplied per kg of fuel	11.788	kg/kg
Share of the carbon burnt only to CO	4.0000	%
Molar mass of the dry flue gas	30.332	kg/kmol

Notes for this case

- Carbon balance: every kmol of carbon burnt gives one kmol of CO_2 + CO. Sulphur and fuel nitrogen are ignored, as in the textbook method.

Formula and method

$$n_{dg} = \frac{C/M_C}{CO_2 + CO}$$

$$m_{dg} = n_{dg} \sum y_i M_i, \quad V_{dg} = n_{dg} V_m$$

$$m_a = n_{dg} \frac{N_2}{0.7905} M_{air}$$

Variables

C	Carbon in the fuel (burnt carbon, by mass)	-
CO_2	Carbon dioxide (dry, by volume)	-
O_2	Oxygen (dry, by volume)	-
CO	Carbon monoxide (dry, by volume)	-
m_{dg}	Dry flue gas per kg of fuel	kg/kg
V_{dg}	Dry flue gas per kg of fuel at 0 °C, 101.325 kPa	m³/kg
m_a	Air supplied per kg of fuel	kg/kg
f_{CO}	Share of the carbon burnt only to CO	-
M_{dg}	Molar mass of the dry flue gas	kg/kmol
n_{dg}	dry flue gas per kg of fuel	kmol/kg
N_2	nitrogen by difference, $1 - CO_2 - O_2 - CO$	-
M_C	atomic mass of carbon, 12.011	kg/kmol

$y_i\$, \$M_i$	volume fractions and molar masses of CO_2, O_2, CO and atmospheric nitrogen	-, kg/kmol
V_m	molar volume at 0 °C, 101.325 kPa, 22.414	m³/kmol
M_{air}	molar mass of dry air, 28.96	kg/kmol

Method and standards

Every kmol of carbon burnt makes one kmol of CO_2 + CO, which fixes the moles of dry gas; the nitrogen in it fixes the air supplied.

Assumptions and limits

- Fuel nitrogen and sulphur neglected. An Orsat absorbs SO_2 with the CO_2, and the air's own 0.04 % CO_2 is counted too, so the carbon-bearing moles are slightly overstated.
- The nitrogen by difference is given the molar mass of atmospheric nitrogen (N_2 with argon and air CO_2, 28.16 kg/kmol), not 28.01; the textbook form uses 28, so the two differ by under 1 %.
- Carbon entered is the carbon actually burnt.

References

• Carbon and nitrogen balances (textbook)
• IUPAC 2013 molar masses; ASME PTC 4-2013 air

Report details

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Method last reviewed	12 November 2026
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/boilers-power-plant/combustion/flue-gas-per-kg-fuel-orsat

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.